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NEW ENGLAND WATER WORKS ASSOCIATION.
ORGANIZED 1882.

Vol. VI. December, 1891. No. 2.

This Association, as a Body, is not responsible for statements or opinions of any of its members.

FALL MEETING.

SEPTEMBER 29TH, 1891.

A party of over fifty members and friends of the New England Water Works Association met at Boston on Tuesday morning, September 29th, 1891. Proceeding by special car as far as Salem they were met by representatives of the Standard Thermometer Company, by whose invitation they had come to visit the factory of that Company at Peabody. The party was transferred by horse car to the stand pipe of the Peabody Water Works, where the working end of the electric indicator made by the Standard Thermometer Co., was exhibited and explained, after which the Town Hall of Peabody was visited, where the dial end of the same indicator was examined.

The factory of the Standard Thermometer Co. was next visited and a pleasant hour was spent in examining the manufacture of the specialties made by this Company in detail. It is but fair to record the fact that the processes of manufacture give evidence of a skilled and intelligent direction to an unusual degree. After leaving the factory the party returned to the Salem depot and thence by train and ferry to the Corinthian Yacht Club House at Marblehead Neck. Here an excellent dinner was served under the auspices of the Standard Thermometer Co., at the conclusion of which a vote of thanks was tendered that Company for the courtesies and entertainment they had extended to the members of this Association. A direct return was then made to Boston. The following members and guests were present:

MEMBERS.

Charles F. Allen, Treasurer, Hyde Park, Mass.
L. M. Bancroft, Commissioner, Reading, Mass.
Dexter Brackett, Assistant Engineer, Boston, Mass.
G. F. Chase, Superintendent, Taunton, Mass.
W. F. Codd, Superintendent, Nantucket, Mass.
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Willard Kent, Civil Engineer, Woonsocket, R. I.
Patrick Kieran, Superintendent, Fall River, Mass.
W. F. Learned, Civil Engineer, Watertown, Mass.
J. W. Morse, Superintendent, Natick, Mass.
A. F. Noyes, City Engineer, West Newton, Mass.
J. H. Perkins, Superintendent, Watertown, Mass.
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C. J. Underwood, Engineering Record, New York City.

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George Goodhue, Concord, N. H.
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Henry Beatje, Water Board, Peabody, Mass.

D. B. Lord, Water Board, Peabody, Mass.
Mr. Littlefield, Water Board, Peabody, Mass.
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W. S. Nevins, Salem, Mass.
J. N. Smith, Boston. Mass.
George L. Wilkinson, Holliston, Mass.
C. A. Wales, Water Commissioner, Holbrook, Mass.

By accident the List of Exhibits at the Hartford Convention did not include Selden's Patent Packing exhibited by Randolph Brandt, New York.

THREE YEARS' EXPERIENCE WITH A DIRECT PUMPING SYSTEM.

BY

GEO. F. CHASE, Superintendent, Taunton, Mass.

The subject of this paper was announced several weeks before a line had been written. A more appropriate title for what is now presented would be:—"A Brief History of a Direct Pumping System, by one who has had Three Years' Experience as Superintendent of the Works."

The treatise on "Hydraulic and Water Supply Engineering," by J. T. Fanning of this Association, is doubtless well known to all the members, and regarded as a standard authority. Probably the majority of hydraulic engineers, if not all of them, would agree with Mr. Fanning in putting the direct pumping system of water supply lowest in the scale of efficiency and trustworthiness.

From the Manual of American Water Works, published by the Engineering News Co., it appears that in New England there are only eight cities and towns which depend for their supply upon the direct pumping system alone. There are only two which have the Holly pumps alone, namely, Taunton and Bangor, and of these, Bangor depends also in part upon water wheels. So that Taunton is apparently the only place in New England which places sole reliance upon the Holly system of direct steam pumping, without a stand pipe. The writer may, then, be pardoned for thinking that the estimate of New England engineers of the Holly system of direct pumping is based more upon theoretical grounds, than upon the results of practical experience. It may, therefore, interest the members of the Association to know what has been the experience of Taunton; how far theoretical objections to a direct pumping system have been realized in practice; how far difficulties have been overcome; and how far the system has proved itself to have positive merits.

The success of any system depends as much upon the management, as upon the system itself.

From the outset, the Taunton Water Works have been under the special charge of three Water Commissioners, each of whom is elected by the City Council, for three years, one being chosen each year; so that in the event of changes, there would always be upon the Board at least two experienced members. Practically, the Board has the same President now which it had in 1876, and of the remaining two, one has served since Jan. 1, 1880, and the other since March 23, 1881, being elected at that time to fill a vacancy caused by death. Two of these members have been for years the managers of large and important manufacturing establishments, and the third is the leading physician of the city.

The control of the works has been chiefly in the hands of these Commissioners, and of the officers whom they have employed to execute their will. It is evident from what has been said that the City Council, and the people whom the Council represent, must have confidence in the Commissioners to continue them in office so long, and their ability and integrity is a guaranty of wise and competent administration.

If, therefore, the works should prove seriously defective, the cause would have to be sought in the character of the system. What are the facts?

The supply has been used for domestic, manufacturing and fire purposes. Fifty-five pounds is the domestic pressure maintained at the engine house. At the office, up town, by an Edson gauge, the pressure is 40-45 lbs. The usual fire pressure is 100 lbs., but has been varied, according to circumstances, from 80 to 125. At the office, it is usually about 90 lbs.

There has never been any failure of the pumps to maintain an adequate fire pressure at the engine house. Once or twice in the history of the works, there has been a failure to keep up the pressure at the hydrants. This we shall see, in the course of the paper, was due to other causes than the direct pumping system.

Occasionally, complaints come to the office of a poor domestic supply. Investigation has shown in such cases, that the trouble was in the service pipe, and a good supply was obtained as soon as the service pipe was cleared out. The writer has carefully perused the annual reports of the Chief Engineer of the Taunton Fire Department from 1877 to 1890 inclusive. The facts in regard to the relation of the Water Works to the Fire Department, whether favorable or unfavorable to the hydrant system, are candidly set forth in this paper.

The final test of the hydrant system, before being accepted by the city, was made Dec. 2, 1876. The following quotation is from the report of the Chief Engineer of the Fire Department for the year ending Dec. 3, 1877:

"The experience we have had with our hose companies the past year will warrant me in saying that the services rendered by them can scarcely be overestimated, especially in the early stages of a fire. In proof of such services the record shows that of the twenty-one alarms of fire the past year, and a majority of them working fires, the use of the steamers has been required nine times. It should not be inferred from this, however, that I estimate the

service of the steamers of little account, for such is not the case by any means; for no city can dispense with them in safety; but, in the early stages of a fire, a ready and quick hose company with an abundant supply of water from our hydrants will, in many cases, prevent a disastrous fire."

The report of the Water Commissioners for 1877 contains the following significant passage: "There have been ten fires that have occurred within reach of the water pipes and hydrants, since the works were completed, and in no instance has the machinery or pumps failed to respond promptly and efficiently for fire service.

"Some have attributed the failure to obtain suitable pressure at the Whittenton fire last March to our system of works, but there is abundant proof that there was a fire pressure in all the water pipes of the city, and within a few rods of the hydrants in the mill yard, to which the hose was attached at the time of that fire."

The writer has made careful inquiry in regard to the fire to which allusion is made above, and is fully satisfied that the true cause of lack of pressure at the hydrants, was due to the presence of stones in the pipes of the mill yard, left there by the carelessness of the men who had been employed in the work of laying. It will be observed that the Chief Engineer of the Fire Department, in his report for the same year, made no criticism of the water works. As a matter of fact, the loss at that fire was $20,000, on a plant worth nearly half a million.

In the Fire Department report for 1878 occurs this passage: "It gives me pleasure to report that the fire of the Taunton Tack Works in July, proved without a doubt the success of our water works for fire purposes. Six line of hose were attached to hydrants for five successive hours and during that time no variation in the supply of water from the hydrants was perceptible, and a number of gauges connected with the water pipes in the various parts of the city showed a uniform pressure. And I am convinced that if emergency required, a still larger number could have been used, with the same result; and the citizens will concur with me in saying that with a well organized Fire Department and our present water works, in all probability we shall not have to record again a large fire in the centre of our city."

In 1880, the Chief Engineer of the Fire Department writes: "The large number of fires the past year with the small loss of property, proves that a well organized Fire Department, prompt to the call of duty, and a bountiful and reliable water supply are a sure protection against a destructive conflagration which has proved so disastrous to a number of cities in the state the past year."

In 1881, he writes: "There are 311 hydrants, an increase of 27 during the year, which have given us plenty of water and good pressure whenever used.

* * * * * * * * * *

"The most destructive fire was one of the rolling mills of the O. C. Iron Co., East Taunton, which was over four miles from the centre and outside of the water limit."

In 1882, he says: "The hydrant service has been good and in no case has it failed to give an abundant supply." There were 30 fires during this year.

The years which are omitted here contain nothing of special importance.

In 1885, when the length of main pipe had increased from 28.88 miles in 1877 to 48.54 miles in the latter year, and in the number of services from 651 to 2523, the report of the Chief Engineer of the Fire Department contains the following: "There are 415 hydrants, an increase of five since my last report. Only in one instance have they failed to give an abundant supply and good pressure, and that was at the fire at White's slaughter barn where it was found necessary to connect an engine to a hydrant. This difficulty has been remedied by connecting the Winthrop and Cohannet street pipes through Highland street." It is interesting to note, in connection with this mild criticism, that the above fire occurred at a point about three miles from the pumping station. The water, to reach the hydrant used in that fire had to pass through about 1¼ miles of 20-inch pipe, 1690 feet of 16-inch, 325 feet of 12-inch, and about 1½ miles of 6-inch. The hydrant was about 500 feet from a "dead end." Obviously, whatever defect there was here, was not the fault of the pumping machinery.

The report of the Fire Department for 1886 contains the following: "There are 450 hydrants, an increase of 35. The hydrant service has contributed largely to the success of the Department during the year. The pressure has been all that was required, except in the district covered by the Bay street main which is only an 8-inch pipe."

"In this district are all the buildings in ward 8, most of Washington street, including Albro's mills, Reed & Barton's works, State Lunatic Hospital, Whittenton Grammar School, and Whittenton Mills, all high buildings. At a fire on Bay street near Jackson, Sept. 5, a line of hose 150 feet was run out from a hydrant, and the pressure did not throw water as high as an ordinary cottage house. I reported it to the water department and found that a pressure of 125 lbs. was maintained at the pumping station, which would give a pressure of 100 lbs. on the level where the fire occurred, if the pipes were large enough to supply the demand. The alarm was given at 9 in the morning when they were drawing largely for domestic use. The increased number of services for manufacturing and domestic purposes had rendered it impossible to maintain through the present main a fire pressure at any of the hydrants in the above locality, sufficient to control a fire of any size, if it should occur in the day time, especially in any of the high buildings."

In 1887, the Water Department replaced the 8-inch pipe referred to in the above passage by a trunk line of 16-inch main, running from the 20-inch main a distance of 2.02 miles, and supplying the heart of this thickly settled ward.

In regard to this improvement, the report of the Chief Engineer of the Fire Department for that same year says: "The new 16-inch pipe, laid through Arlington, Purchase, Bay and Whittenton streets, is a great improvement to that part of the city, and will give nine good fire streams at Whittenton, as proved by a test made Oct. 29. The old 8-inch pipe would only furnish three streams and required greater pressure at the Pumping Station."

This brings us down to the period of the writer's connection with the works.

The Chief of the Fire Department in his report for 1888 says: "The city has been free from any great loss the past year and, considering the nature and material of most of the buildings, we have been remarkably fortunate. This is due in a great measure to the care and attention paid by property holders and occupants of buildings in guarding against fire and to the vigilance of the police and their promptness in giving alarms. I have always found occupants of buildings ready and willing to comply with a request to remove combustible material when found on their premises."

At the time these words were written, there had been in Taunton, within the district covered by water pipes, since the water works were built in 1876, 400 fires; yet no fire had ever got away from the building in which it started, and the largest loss in any one fire was $40,000 in 1877, at the fire of the Taunton Tack Works. That this immunity was due to something besides good fortune, the experience of the next two years abundantly illustrates.

On Oct. 22, 1889, about twenty-five minutes before two o'clock in the afternoon, fire was discovered, burning rapidly, in a two-story wooden stable in the rear of Main street. In the vicinity of this stable was a perfect tinder box. Covering several acres, were one-story and two-story dwelling houses, closely packed together, stables, saw-mills, planing mills and lumber yards, all dry as dead leaves.

The fire was in the rear of the City Hall, within stone's throw of the Water Commissioner's office, and about one hundred feet from the end of the repair shop of the water works. It was discovered by the foreman of the water works, as he was about to enter the shop. He rushed to the corner of Main street and notified the man who had charge of the key of the alarm box near by, to pull in an alarm. He, himself, rushed back to the shop and attached a small 1½- inch rubber hose to a faucet and, for several minutes before the Fire Department arrived, played upon the fire, and checked it from spreading. In a very few minutes the Chief Engineer was on hand. Taking in the situation at a glance, he quickly pulled in a general alarm, to call out the whole Fire Department, and to be ready for the worst that might happen. The first alarm sounded at 1.38 P. M. At that time, the writer was sitting in a barber's chair, in the midst of a shave. It could not have been more than ten or twelve minutes before he was at the scene of the fire; he then counted five lines of hose from hydrants, and the fire seemed to be partly under control. Two steamers were present, in case they should be wanted, but they were not used.

According to the report of the Chief, the alarm was given at 1.38 P. M., and the relief call sounded at 2.45 P. M. In one hour and seven minutes from the first alarm, a fire which, if neglected, might have devastated acres and destroyed thousands of dollars' worth of property, was put completely out. The total loss, mostly covered by insurance, was $1139. According to the engine records of the water works' office, the fire pressure of 100 lbs. was on for one hour and four minutes. This agrees with the record of the Fire Department; for it takes just about three minutes from the first stroke of the alarm bell, to

get up the fire pressure upon the pumps. Can a steamer get up steam any quicker? At this time, the pumping machinery of the water works could have easily supplied 14 streams of 150 gallons a minute each, or upwards of 10 streams of 200 gallons a minute, and still have kept up the domestic supply.

You will be interested after this account of the possibilities of a disastrous fire, to hear the report of the Chief in regard to this case. He says: "The third alarm was given in one instance. At the burning of Wilbur Brothers' stable, October 22, the whole Department, except the volunteers, was called, as a precautionary measure, owing to the nature of the surroundings, but only the first relief used."

The following is the quiet way in which he reports the fire itself: "Oct. 22, 1.38 P. M. Box 5. General alarm. Two-story wooden stable on the south side of Main street, in the rear. Owned by J. Wilbur and Bros. and occupied by them. Value of building $750; damage $650; insurance $550; insurance paid $550. Adjoining building owned by S. P. Bliss and occupied by Dr. Pero as a stable, damaged $22. Value $500; insurance $400; insurance paid $22. Value of contents in Wilbur building $707; damage $467; insurance $450; insurance paid $425. Present – Engines 1 and 2; Hose 3, 4 and 5, and Hook and Ladder 1; Chief, and Engineers Baker, Mason and Carpenter. Relief 2.45 P. M."

Do you say this was good luck; the fire started in the day time and therefore was soon discovered, and the Fire Department quickly rallied?

Last year, 1890, in the same dangerous locality, not 250 feet from the above stable, a fire broke out at night. This is the Chief's account:

"Oct. 13, 8.45 P. M. Station 52, Monday. Third alarm. Wooden planing mill in the rear of Main street, owned by E. P. Bassett and occupied by E. P. Bassett as a carpenter shop and by Thomas Knowles as a turning mill. Cause, incendiary. Value of building $2000; damage $500. No insurance. Value of contents $3000; damage $500. No insurance. Present—Engines 1 and 2; Hose 3, 4 and 5, and Hook and Ladder 1 and 2, Chief, and Engineers Baker, Mason and Carpenter."

From the engine records of the water department, it appears that a fire pressure of 100 lbs. was kept up for one hour and five minutes, and the pumping machinery could have easily furnished 10 more hydrant streams of 200 gallons a minute each.

Again, it may be said you have not proved the efficiency of your pumping system. You have only shown the excellence of your Fire Department.

The writer distinctly remembers that, a few years before the construction of the water works, he saw, on fire in broad daylight, in the outskirts of the city, a large barn, containing several tons of hay, farming tools, several horses and cows, and, in the cellar, some hogs. He also remembers that he saw this barn completely destroyed, with much of its contents, including a part of the live stock, while two steamers and their companies were standing idly by, because there was not a drop of water to play upon the fire. Today, if a fire

happened in the same locality, four effective hydrant streams would be available, and three or four good timely streams would have saved that barn.

A water supply is useless for fire protection without an efficient Fire Department; but a Fire Department is equally helpless without a water supply.

Two passages are quoted from the Fire Department report of 1890:

"The largest loss for the year was caused by the burning of Briggs' grain elevator, Dec. 1, which was $23,066.68. The fire started near the first floor near the centre, and by means of elevators, shoots and stairways, soon communicated to all parts. The location of the building prevented effective work on the river side, and the large quantity of grain stored in bins rendered it unsafe to work on the inside. The value of building and machinery was $24,000; the loss on the same, $14,224.70. The value of contents was $11,-216.98, which was almost a total loss." Referring to the same fire, the report says: "The hydrant service has answered all requirements, except at the Weir, Dec. 1st, when it was necessary to limit the number of streams to eight and call the steamers into service. In certain sections of the city a limited number of streams only can be used, which will be governed by the capacity of the street mains.

"I would urge the necessity of additional four-way hydrants on City Square, three on West Water street, two on Cohannet street, below High, two on Wales street, near Mason Machine Works and the Old Colony shops, and two on Oak street, to avoid running long lines of hose, which reduces the pressure at the nozzle."

In regard to the fire where only eight streams were obtainable, it should be said that the pumping machinery could have furnished double that number. But this grain elevator was about 2½ miles from the Pumping Station, and more than a mile of the distance was covered by 8-inch pipe. When, however, the four-way hydrants called for in the report of the Chief for West Water street have been set, as they will be this summer (one of them is set already), this difficulty will be overcome. The 2½ miles mentioned above alludes to only one trunk line. But since last season, by the closing of a long gap between dead ends, this street has been supplied by three trunk lines, flowing into one. Of these, one is about a mile of 8-inch pipe, fed by a 16-inch; a second is 4300 feet of 8-inch, fed by a 10-inch; and the third, fed by a 12-inch, is 1.7 miles of 8 and 6-inch pipe, rather more than half of which is of the larger size. Moreover, this section is on a lower grade than the Pumping Station, so that, generally, 90 lbs. fire pressure for this locality is as effective as 100 lbs. at the centre of the city.

How far, then, has the Holly system of direct steam pumping in Taunton succeeded? Much space has been devoted in this paper to Fire Protection, as that is one of the most important functions of a water supply. There have been some elements of weakness, not peculiar to direct pumping.

Gravity systems often have their mains too small. With gravity supplies, cities and towns outgrow the facilities of their early plants.

From Jan. 1, 1877, to Jan. 1, 1891, within the territory supplied by the water mains, Taunton has had 522 fires. Yet, practically, no fire had extended beyond the building in which it was first kindled.

In a city having an assessed valuation today of $17,823,032, and a valuation of buildings, excluding land, of $8,075,800, the largest total loss by fire in any one year since the construction of the water works was $76,950, divided among 21 fires. During the six years from 1885 to 1890 inclusive, the value of buildings and contents where fires actually started, amounted to $1,653,-242.81. The total loss by fire was $176,330, or 10.6 per cent. of the value. The actual loss to the owners in excess of insurance was $22,354.94—about $1\frac{3}{10}$ per cent. of the valuation. This loss was divided among 310 fires.

Mr. Shedd has suggested the following formula to determine the number of fire streams of 200 gallons each, which a city should be able to supply with its pumping machinery or reservoir:

Number of streams=$\sqrt{\text{population X .005.}}$

Applying this to the population of Taunton by the census of 1890, namely 25,389, the machinery should be able to pump enough water to supply 11 streams. As a matter of fact, it can pump without danger to the machinery, water enough to supply 14 streams of 200 gallons each at the hours of maximum domestic consumption, and the water itself could not fail the pumps, so long as a flow could be obtained through a 16-inch river pipe, with never less than a foot and a half head at the very lowest tide ever experienced, and by a 30-inch pipe with never less than two and a half feet head at the lowest stage of the river.

Mr. Freeman, in his paper on "Some New Experiments and Practical Tables Relating to Fire Streams," published in the Journal of this Association for March, 1890, says: "Although we should be prepared to supply any particular stream with 300 or 350 gallons, yet even at a great fire, at any given moment, some steamers will be stopped, some hosemen will be along the skirmish line at work with smaller streams, wetting down roofs and washing incipient flames off from wooden cornices and mansards; and taking all these things into account, I believe that we ought, in our computations and estimates for water supply, to provide at the very least an average of 250 gallons per minute for each stream in the business centre of a city, or round about any extensive factory. In a dwelling house region less will suffice."

At City Square in Taunton, within a radius of 200 feet of the centre of the Common, at least ten such streams would be available without the use of steamers. None of the buildings are more than three stories high, and some of them have only one story. There is on this square a reservoir, for steamer use, holding 40,000 gallons, which, in an emergency, would give six streams additional of 250 gallons each for 20 minutes, from the three steamers kept in commission. Practically there have been several threatening fires on this square, since the construction of the water works, but they have always been extinguished with the use of not more than three or four hydrant streams.

Human power is not invincible. Taunton may sometime take her turn with a disastrous fire. If she does, then, for the first time, she will have an experience familiar to cities and towns with gravity and reservoir systems.

Mr. Fanning says the direct forcing method does not provide for the deposition or removal of impurities after they have passed the engine. True; but the water may be filtered before it reaches the pumps, and, moreover, the sediment may be removed, as it is in Taunton, by general flushing of the mains, performed section by section during the hours of minimum domestic consumption at night. On the other hand, do we hear nothing of bad water from vegetable growths in storage reservoirs?

Mr. Fanning says that double or triple sets of hands are necessary to whose integrity and faithfulness, night and day and at all times, the works are committed.

Well, God help the city or town which, in this land of schools, churches and machine shops, cannot find a double set of hands to whose skill and faithfulness can be trusted their pumping machinery, by day or by night. The Taunton water works had two engineers in 1876. It has the same two engineers now it had then, and the writer would trust his life to either of them. The firemen are faithful men, both of them competent to run the engines. The present Chief Engineer of the Fire Department has served in that capacity for ten years; his predecessor held the office for 21 years.

If it costs more to have duplicate machinery and duplicate hands to run it, under the direct system, it costs more for fire steamers under other systems.

Do we never hear of dams giving way, of stand pipes collapsing, of reservoirs leaking? Do rotten pipes never burst in gravity systems? Is there never political jobbery which puts incompetent men at the head of Gravity water works?

In conclusion. For the best results upon any system, all influences must work together in harmony for the good of the community.

If weak points are found in the Taunton system, they are strengthened. If the Chief Engineer of the Fire Department asks the City Council for anything, he gets it. If the Water Commissioners ask the City Council for anything, they get it. If the Chief Engineer of the Fire Department asks anything of the Water Department, he gets it. Sometimes, there is a little delay, some need of argument, and judicious work; but, in the end, all comes out right.

Doubtless, for very large populous cities, the direct pumping system would be very costly and altogether impracticable; but, for small cities and towns in a flat country, the Holly system of direct pumping is entirely practicable; May it not be said that, in Taunton, 15 years of prosperity, with scarcely a ripple of disaster, has proved, that under good management the Holly system of direct steam pumping is a triumphant success?

DISCUSSION.

THE PRESIDENT. The paper of Mr. Chase is now open for discussion. We should be pleased to hear from Mr. John R. Freeman.

MR. FREEMAN. Mr. President and gentlemen, I did not come here expecting to take part in this discussion; I came here rather to listen and to learn. I have been very much interested in Mr. Chase's able presentation of as good a case as can be made for a direct pumping system. (Laughter.) And as I have listened to his paper, I have been led to question whether the remarkable success in Taunton for so many years had not been in large measure due to the rare good fortune of Taunton in having, in the first place, been able to profit by the counsels of our energetic member, Mr. Billings, and later by the care of Mr. Chase.

There certainly must be some ground for the belief among insurance men that direct pumping is less safe than a gravity system. In my own experience I have been more and more coming to the conclusion that the force of gravity is almost the only force with which we have to deal, which does not now and then get out of order. My experience has been that the devices for direct pumping such as are adopted in many of our mill yards for fire protection will operate as a general thing in a very satisfactory way, perhaps four times out of five, but cannot be relied upon to take the place of gravity supplies.

I have been interested in Mr. Chase's statement as to the cause of the partial failure of the water pressure at the Whittenton Mfg. Co.'s fire, and I would like to ask whether there was not some years ago a failure in the same yard of a direct response to signals for fire pressure. I know there has been some kind of a vague tradition hanging about our office that something of that sort occurred at one time, and I would be interested to hear whether that tradition has any foundation in fact.

MR. CHASE. With regard to the question of Mr. Freeman, I haven't found any record of such a failure as he speaks of, though there has been something in the air about it. Whatever occurred, occurred before my time, and perhaps Mr. Billings can give more light than I can on that subject.

MR. BILLINGS. I don't know that I can throw it on to my predecessor (laughter), and I don't know that I want to, because, while I cannot quote the exact figures, nor produce the records, yet I have a very clear impression that the difficulty to which Mr. Freeman refers was one which had nothing to do with the power that sent the water along to the point where it ought to have been used. There were at least two lines of mains running into the mill yard, and at one point and another there were gates, I don't know whether those gates were open or shut, and there were several things that were never satisfactorily explained, as I remember it; but there was never, I am perfectly sure, anything to show that there was any failure on the part of the pumping machinery to respond to any pressure as wanted. The case to which Mr. Freeman refers occurred before the 16-inch main was laid, and there was only an 8-inch pipe supplying the Eighth ward. It was a very long line of 8-inch

pipe, altogether too long a line to pretend to furnish the water needed at that point; so whatever difficulty may have occurred at that time might have occurred just as well had the water been under the force of gravity instead of under a pumping force.

MR. ALLIS. I would like to ask Mr. Chase if he has a duplicate set of pumps so that in case one gives out he may attach another one.

MR. CHASE. Yes. When the system was put in there was a duplicate set of pumps, of course, but in the course of time even the two engines, two sets of pumps, would not have been sufficient to have taken care of a very large fire in the centre of the city during the hours of maximum domestic consumption; and it was the opinion of everybody in the water department last year that there ought to be a new engine to replace one of the old ones. You remember something was said in the paper which I have read about quiet and judicious work. When the petition for an engine was first presented to the Council, it was referred to the Water Committee. The Water Committee, as a whole, were not in favor of it. I prepared a statement, after having gone over the pumping record for the two engines, showing what they had been doing and were able to do, and that we couldn't get more than three streams in the centre of the city at mid-day if there was a great fire. I emphasized the fact that they might see the whole city square in ashes and have to reflect that the whole thing might have been saved if they had voted $25,000 or $30,000 for their pumping machinery. The result was that finally the committee voted unanimously to have the engine. The matter was reported back to the Council, and they were so impressed with the matter it was put through in one evening, and we now have the engine, and give those 14 streams I speak of, whereas, last year we could not have done anything of the kind.

[NOTE—The discussion following was written after the meeting at which the paper was presented.—EDITORS.]

J. NELSON TUBBS. I have had some experience with the operation of a direct pressure system of water works in Rochester, N. Y., for the past 17 years.

In designing water works for that city I provided a dual system with two lines of pipe distribution in the business centres of the city. The domestic supply was furnished by gravity and the water for suppression of fires in the business centres among high buildings and in manufacturing areas was supplied by pumping, either by steam or water power or both, under direct pressure from the pumps.

The duplicate provision was made for purposes of economy as well as in the line of a more effective fire pretection in the areas occupied by the most valuable city property.

The direct pressure pumping system reached completion one year in advance of the gravity supply, during which period the whole distribution system to the extent of about 50 miles of pipe was operated on the direct pressure plan and with marked satisfaction and success.

The direct pressure plant now has a pipeage of about 15 miles and in addition to the fire protection effectively furnished in the localities into which its mains are extended, it operates the motors for elevating seven roadway lift bridges over the Erie canal, operates about seventy freight and passenger elevators and furnishes all the water used in the city for street roadway sprinkling. These uses are far in excess of those contemplated by me when designing the works, and will, if continued and extended, soon cripple the works as a fire extinguishing apparatus.

Thirty fire streams have been thrown at once from this plant. During the past 17 years of constant use it has never failed to fully respond to all demands made upon it for the suppression of fires without the intervention of fire steamers, at all times affording protection far beyond the limits of its pipe distribution, in one instance at least, controlling and suppressing a fire of some magnitude 1700 feet distant.

The leaks and breaks upon this pipe distribution have been no more frequent than upon gravity lines of the same length and the same pumping machinery is now in use as at the first. The ordinary pressure is maintained at 70 pounds at the pumps and the fire pressure frequently reaches 125 pounds.

As a device for the suppression of fires I believe it to be unequalled, and I am inclined to the opinion that the general adoption of this or some similar system in all large cities and manufacturing towns where valuable buildings, merchandise and industries are concentrated, will be found the most effective and cheap means for fire protection.

I have thus briefly stated my experience with the direct pressure system, to give some standing to the following opinions.

1. I concur with Mr. Chase in the belief that for small cities and towns in a flat country the direct pressure system is entirely practicable.

2. I believe it may be successfully employed in towns and cities of considerable size and population for a general supply, by a proper arrangement of distribution mains of sufficient capacity and a proper duplication of pumping machinery.

3. I believe, however, that in a large majority of cases when applied for a general supply, it can be operated with much more economy in connection with a stand pipe or reservoir, so that continuous pumping may not be required until a consumption of water nearly equal to the full capacity of the plant has been reached. During the intervals in which the domestic supply is furnished by the stand pipe or reservoir, the fires under the boiler are banked, requiring but a few minutes in case of a fire, in which to raise the steam and give direct pressure in the mains, the reservoir or stand pipe then to be automatically cut out of connection.

As previously intimated I further believe that the direct pressure system for use solely for the extinguishment of fires in large cities, in locations where are concentrated large manufacturing industries, elevated buildings compactly built, or large warehouses containing rich and valuable products, the plan of

protection from fires by the direct pressure system has no equal, either in *efficiency* or *economy*. The mains to be used exclusively for the purpose and the pumping machinery to be placed at one or more convenient locations by sea or lake or stream.

5. I am aware that engineers of prominence have so much confidence in a general supply to a large city by direct pressure from the pumps, that they have felt justified in advising the construction of new works on this plan to supply a population of 200,000, where the physical conditions seemed to them to warrant no other equally advantageous arrangement. See the recent report of Messrs. Holman, Benzenberg and Hermany to the Board of Public Works of Kansas City, Mo.

Their recommendation is made in the face of the fact, that the pumping is against a head for domestic purposes of 340 feet, for ordinary fires of 430 feet, and for extraordinary fires of 455 feet.

The time limit for a review of Mr. Chase's paper allows no opportunity for extended argument, so that I have contented myself with the bare statement of certain propositions, the results of a somewhat extended experience, but I trust they are so conservatively stated as to commend them to the members of the Association.

W. H. Richards. While realizing that it would be presumptuous to question the conclusions of the high authorities quoted, there must, as Mr. Freeman remarks, be some grounds for the general belief that the direct pumping is less safe than the gravity system.

Every engineer knows, many from sad experience, that a sudden increase in pressure results in a severe strain on the pipe system, and hence a liability to rupture. So that a sudden increase of 50 pounds or more is liable to rupture a main and reduce the pressure to zero and thus deprive a section of water entirely, at the time when most needed. That an accident of this kind is not recorded does not disprove its liability. A man may live for years over a powder mill, but that does not make it a safe place of residence.

A hasty examination of the records would indicate that the number of leaks per mile of main in Taunton has been less than the average, which indicates a larger factor of safety in the pipe than usual, or better workmanship, or both, and no figures are available showing the bursts in the house plumbing, but possibly in the future this weakness may develop itself.

Experience proves that an occasional sudden increase in pressure on pipes results in a final rupture, which does not take place where the pressure is constant or nearly so, and for this reason a direct pressure system, where the pressure is increased in case of fire, would seem to require much thicker pipes, and hence greater cost than a gravity system to secure equal safety. Whether this is the case in Taunton I have no means of knowing.

GEO. F. CHASE. As regards house plumbing in Taunton, there have been instances of the bursting of the house pipes while the fire pressure was on; but such cases have been very rare and were for the most part, attributed to weakness of the pipes.

Such leaks as have occurred in the mains have almost always been in the joints or around the stuffing box of a gate and were very soon repaired.

A direct pumping system should alwya shave two large supply mains from the pumping station, making a duplicate system for a reasonable distance, so that there will be slight chance of a total loss of supply in the event of a large leak.

The writer does not attempt to deny that there must be a greater factor of safety in the strength of the pipes than in the case of gravity systems and a corresponding increase of cost. This is balanced, however, by the diminished cost of the fire department from the fewer steamers required under the direct pumping system.

The whole purpose of the paper has been to show that under proper management a direct pumping system is a practical success and is especially to be considered in planning a supply for small cities and towns in a flat country. No critic of the paper has refuted either of these propositions.

It is very interesting to notice in this connection the following paragraph from "Fire and Water" for Oct. 3, 1891:

"Perhaps the most radical views upon the subject of change in the methods of fire protection in our large cities are those which are ascribed by the Milwaukee Sentinel to First Assistant Chief Musham, of the Chicago Fire Department. According to that journal Mr. Musham, when in Milwaukee recently, expressed himself of the opinion that portable steam fire engines had outlived their day, and that the time is not far distant when the present machine will have become a thing of the past and have been replaced by the high pressure water system.

He is quoted as saying: 'The idea is to build several pumping stations and connect them with the mains. That would make engines unnecessary and instead more hose and ladder companies could be organized. When an alarm was sent in the pumps would increase the pressure as much as necessary. The water could thus be taken directly from the plugs. In Chicago, we would probably need twelve such pumping stations, while in Milwaukee less would be required. The cost of new apparatus and its maintenance is enormous, and stands in no proportion to what the building of such pumping stations would cost.'"

ARE LEAD CONNECTIONS FOR IRON SERVICE PIPE NECESSARY?*

BY

HORACE G. HOLDEN, Superintendent, Nashua, N. H.

One of the principal reasons for organizing our association was to enable us to exchange ideas and if any one should adopt a new method of doing work by which a saving of either time or expense could be made, he was expected to explain the new method for the benefit of any one, who might either profit by his ideas, or perhaps show a yet better way of doing the same thing.

Last fall I had occasion to visit a number of works where wrought iron service pipes were used, and noticed that it was customary with every one to attach the iron pipes to the main pipe, by a short connection of lead pipe, or a goose-neck as it is commonly called.

These goose-necks are in general use throughout the country, and every superintendent who uses them will probably tell you that he considers them an indispensible adjunct to a service pipe for unless the lead connection is used, the ground is liable to settle and break the service pipe off.

I was of the same opinion myself until I came to Nashua and found that such a thing as a goose-neck had never been heard of in that locality. The works there have been in operation nearly forty years, and previous to 1865, the service pipes were mostly of lead; but about that time galvanized iron pipes came into general use, and have continued to be used on those works almost entirely ever since. The manner of connecting the service to the main was as follows: The main pipe was first drilled with a rachet drill. The hole was then tapped out, the service pipe was screwed into it, and laid to the inside of the cellar wall. Some of the mains were tapped on the top, and the service pipe connected by a short nipple and elbow, similar to the manner of attaching gas supplies.

I concluded however that corporation cocks would be an improvement, and ordered some made having the outlet end conform to a corresponding size of pipe. That is the outlet end of the $\frac{3}{4}$" corporations was made to fit a coupling for a $\frac{3}{4}$" pipe. The $\frac{3}{4}$" corporations fitted couplings for 1" pipes, and the 1" corporations fitted $1\frac{1}{4}$" couplings. I then had a "Jones" tapping machine made that would fit all these three sizes of corporations, and I run the service pipe from the main to the inside of the cellar wall without using a lead connection, except in cases where the trench runs through a ledge, and is not excavated straight enough to admit of a direct line of pipe. In that case I

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* This paper was originally intended to be read at one of our experience meetings, but as I was unable to be there I have reserved it for this occasion, although it would come more properly under the head of an experience than it does of an argument.—H. G. H.

occasionally have to use the lead connection. I have never had the slightest trouble with services breaking or leaking, although in many of our streets deep sewers have since been laid close alongside of the mains, and afterward back-filled in a very loose and shiftless manner.

The advantages gained by not using goose-necks are, (1st,) the saving of about one dollar on the cost of each service pipe; and (2d,) in case the service pipe gets plugged by a fish or any other foreign substance, a block tin rod can be easily run through it from the cellar to the main. In laying service pipe I always place a stop cock at the sidewalk, and a stop and waste cock with a union, in the cellars, so that by disconnecting the union any repairs or changes can be made to the house pipe without disturbing the service pipe.

I think that Cambridge and Pawtucket do not use the goose-neck, and if these places can get along successfully without them, I cannot see why all places cannot equally well.

DISCUSSION.

THE PRESIDENT. Mr. Holden's paper is now open for discussion. This is a question which affects, in a pecuniary way all works, and there certainly have been strong reasons presented for the universal adoption of the method suggested. I should be pleased to have many of the superintendents relate their experience.

MR. CODD. I do not see any reason why water service pipes cannot be laid as safely as cast iron pipes, without lead connections; yet I believe it pays to use the lead connections. There is a saving in time, especially if you work out from the side of the street to the main. It is much easier to join a *lead* pipe to a corporation cock than an *iron* pipe, that is, to make the parts of the union joint fit. And it also allows for any settlement of the service pipe and any difference in level between that and the main. It makes allowance also for contraction on account of changes in temperature, and it also makes it much easier to change the direction of the pipe, if the trench is not dug at right angles with the main.

MR. RICHARDS. While excavating a deep sewer trench lately which crossed all the gas service pipes and all the water service pipes there were in the street, I found the gas pipes were connected with the main without lead, as Mr. Holden suggests, and they nearly all pulled out when the sewer trench was back-filled; but with the water service pipes there was no difficulty. That confirmed my previous impression that there should be a piece of lead on the end of the service pipe.

MR. ALLIS. I see from the discussion so far that quite a number use iron service pipes. We don't use them, but use lead wholly. When we take out the iron pipes we find that they are filled with rust so that very little water can get through them. I don't know but that is owing to the peculiar nature of the water, and I would like to know whether it is something exceptional or not. We use corporation cocks and put in lead pipe to the side of the street and go no further.

MR. HOLDEN. The cities that can afford it use lead pipe. If you will consult the Manual of Water Works, you will find that nearly three-quarters of the towns and cities that have water works in the United States use wrought iron pipe of some kind. Of course lead pipe is preferable to anything else, but it is much more expensive.

MR. WHITNEY. I would like to ask Mr. Allis if the iron service pipes which he has tried are coated over with some class of coating, if he has tried galvanized, or tarred, or enamelled, or any of the various pipes there are in the market, and if he had found the action of his water to be the same on them all?

MR. ALLIS. I will say I never have used any iron since I have been connected with the works, and the only iron pipes I take out, evidently never were coated. I think they were put in many years ago, and were without any coating.

THE PRESIDENT. We have with us a friend of long experience who, I think, can give us some valuable information upon this question of service pipe, and I will call upon Mr. Gow, the superintendent of the Medford Water Works.

MR. GOW. Mr. President, I understand Mr. Holden's idea is to get rid of a lead goose-neck in connecting iron pipe. I don't think it advisable. There is more or less settling of the ground always, and the threads are very apt to break close to the main pipe. If you have a goose-neck, or lead connection, it is much handier to make a connection with the pipe, because you can twist it one way or the other, move it up or down, make it longer or shorter. Where you cut iron pipe you have got to have it just exactly the right length to make the connection. My own idea would be to have the *whole* service lead.

THE PRESIDENT. I would ask Mr. Stacey, of Marlboro, what his experience has been?

MR. STACEY. Mr. President, I think it is largely a matter of circumstances whether you lay iron pipe to the main, or whether you put in a piece of lead. There is much difference in the soil. Our practice is to start from the sidewalk, put in a sidewalk cock first, especially if we have to cross the street to the other side, and I think it is a saving of time, to say nothing about the safety, to use a lead connection. Where it is easy digging, sand or easy gravel, perhaps you can make a trench so the pipe will come fair to the tap of the main. I have had considerable experience with pipe laying, and I have always found that where you have to spring a pipe to get it together you don't have a sure job. The pipe has got to come level and square together to make a good permanent job. Now, to do that in the ground sometimes incurs a considerable expense. If there is a change in the grade of the street of six inches, or perhaps a foot, you don't move your main pipe, and without a lead connection you have got that extra foot of excavation. Our service pipes are laid four feet and a half deep, and I have some main pipes that are covered six feet at the present time. Now, we dig our service trench the usual depth; and when we reach the main we make that allowance for our lead connection, and I think we save much more than the lead connection will cost, even if it

were practical to make a straight connection with the main, and I feel much safer with it. I know it is said gas mains are connected without lead connections. But gas mains haven't the pressure that water mains have; and if all gas works are like ours in Marlboro, you will find that there are many leaks, which don't amount, perhaps, to much with gas, but which, with water, would have to be repaired. While perhaps the escape of gas wouldn't amount to much, the same leak in a water pipe under water pressure of 60 or 70 pounds would amount to a good deal. And while I have no experience with gas pipes in any other place than Marlboro, my impression is that if I was going to make a good, strong, firm connection for a gas pipe, I would put in lead.

There are times when we run against a bell, and with a lead connection we can tap the pipe where it is most convenient, put in an easy turn with a lead connection, cover it up and never have any trouble with it afterwards. The saving in that is more than the cost of the lead connection, to say nothing about the safety. I claim that you cannot make a joint on iron pipe in the ground, unless the pipe is very carefully laid, without bringing a certain degree of strain on the thread. I can see no objection to the lead connection, and I am a firm believer in lead pipe as a service pipe.

When the works were started in Marlboro there had been one or two cases of lead poisoning from lead pipes supplied from wells; and if we had adopted lead pipe the result would have been that we probably should not have put in more than one-quarter of the services we did. On looking the ground over the conclusion was arrived at that cement-lined service pipe was the next best thing to lead. Some didn't think so, and piped their houses with tar-coated or enamelled pipe. The result of that is the pipe is filled up. Galvanized pipe has worked well wherever it has been used, but I have been very cautious in recommending it. Lead pipe to my mind is the only service pipe which should be used, unless an analysis of the water demonstrates that its use is dangerous. I believe there has never been a case of lead poisoning from any water works in New England, and I cannot see any objection to its use, and I can see a great many advantages.

The President. We would be glad to hear from Mr. Brackett as to his experience.

Mr. Bracket. I don't know as I can give very much information on this question, because we have always used lead services, and consequently we have not had experience with iron services, with this exception; that the original services that were laid in Boston were inch and a half cast-iron pipes, and were connected with the mains by a rigid connection, made by means of a brass fitting which was rigid, and united the cast-iron pipe with the coupling connecting with the cock. Those, so far as I know, have never given trouble (of course they were laid at a time when there were few pipes in the streets), but they have at the present time all been removed, with perhaps a very few exceptions, on account of the services filling with rust.

There is one point I have thought of in connection with the use of iron pipe, and that is the difference between a water pipe connection and a gas pipe connection. I think gas pipe connections are generally made from the

top of the gas main with a short upright piece, which would allow of a deviation from a straight line horizontally, and perhaps to a certain extent vertically in making the rigid connections. That is, it would be more easily made with a gas pipe than it would with a water pipe. While it would seem to me from the remarks that have been made, that in Nashua these connections have been used with success for forty years, in other places where they have not been used they are doubtful as to whether they would be successful. But they have not had an experience with them, and I do not see that any one who has had experience with them condemns them. I know that in a greater part of the business portion of Boston it would be utterly impracticable to use them, for the streets are now so full of pipes that there would not one case in a hundred where you could run a straight line from the curbstone to the main. Some of our services are carried down ten or twelve feet in order to get them under gas pipes or steam conduits or hot water pipes or various other kinds of pipes in the streets. In these cases, of course, lead pipe is the only practicable thing to use, and we use it entirely.

Mr. Coffin. I think on the whole there would be an advantage in using lead connections, but I think there is a difference between the different kinds of iron pipe. Mr. Holden speaks of galvanized iron pipe, and Mr. Stacey speaks of cement lined pipe, and so does Mr. Gow, under whose administration I have the pleasure of living. I think it makes a great difference whether the pipe is lined with cement or whether it is not, because the pipe unlined you can bend and straighten to a certain extent, and it might be put in without any disadvantage without the lead connection that Mr. Holden speaks of. It seems to me that cement lined pipe, which is more rigid, and which really ought not to be bent at all to preserve the value of the cement, would be rather hard to put in in a great many places without a lead connection. And the cement lined is a compromise, as I understand it, between the lead and the ordinary iron pipe, and makes a very satisfactory service on the whole. I would like to ask Mr. Holden about what the life of the galvanized pipe is with him.

Mr. Holden. We have some pipes which, as near as I can judge, have been in since previous to 1870; and some of them are still good. Others have been taken out and changed. Most of these original ones were tapped into the top of the main, similar to gas pipe. We have had to change quite a number of them this year, and find the elbow that comes up from the top of the pipe completely filled with rust, while the rest of the pipe remained pretty fair. Another place where we get a good deal of rust is where the brass cock and iron pipe come together. By running a straight pipe, as I do, we can run a rod through the pipe and clean out the rust, and even if the pipe is pretty well plugged up, by cleaning it in this way, it is made good for some time longer, a year or two, probably. I have done it frequently on some of our older pipes, rather than to put in new ones.

Mr. Gow. If the service should happen to be rusted up with no corporation cock, do you shut off your mains to take the service apart?

Mr. Holden. That is the way we had to do. Now we have changed them as fast as we could, and put in corporation cocks. I have corporation cocks

of a size, to conform to the sizes of pipes, with the same kind of a thread, so I can unscrew a three-quarter inch pipe, or inch pipe, by having the line shut off, and insert a corporation cock. Still we have a great many of those old supplies which have been in all of twenty years, and we have had no complaint from them. Our water effects galvanized pipe the least of any water I ever heard of. The Merrimack River water will fill up a galvanized iron pipe in about six or eight years. Our brook water is very clear, and we have very little sediment to fill the pipe.

Mr. Gow. On the works I am connected with, from three to four hundred services of three-quarter galvanized pipe were put in, and some of it was plugged up before it was in six months. There is a difference in galvanized pipe. We had some pipe that was very good, and some of it is in to-day. We use at present black iron inch pipe lined with cement. I found after using the pipe for a year or two that it was of no use to line the pipe and leave the ends of the pipe bare. The ends of the pipe don't meet in the coupling; and, even if they did, they could not make a perfectly close joint and the ends of the pipe rust. I now line the couplings with lead, which brings each end of the pipe close up to the lead, and forms a washer; and on the goose-necks, or the lead connections, I use a fitting with a shoulder inside next to the stop-cock, where a small lead washer can be put in, so there is no liability to rust. We have changed about three hundred of those three-quarter services. We find the rust where the brass and the iron are connected. As I said before, there is nothing, in my opinion, like lead pipe for service pipe, but we can't always have what we want.

Mr. W. H. Hawes. It seems that there is a great deal of difference in the iron pipe and lead pipe. We have always used the lead connections. We first used a great deal of black iron pipe. It was but a few years before they commenced to rust inside the pipe, and the pipes were soon plugged up. We took them apart, and found they were filled with rust. We then concluded not to use any more plain iron pipe, and put in enamelled pipe and galvanized and lead. In my own house I put in black enamelled pipe, and in three years the whole pipe was black, the enamel had all come off on the inside, and I took it out and put in lead. Then we passed a rule in the Board of Commissioners that nothing should be used except galvanized and lead pipe, and we were going on nicely with that until within a short time, our superintendent informs me he has found that the galvanized pipe has flaked off on the inside and plugged up the cocks again, and he don't know but we shall have to confine ourselves entirely to lead pipe. On lead pipe where we have lead from the mains into the cocks in the sidewalk, three years ago, we had several breaks, and when we took it up we found the lead pipe was eaten through. We hunted up the record of where that lead pipe came from, and we found at one time we bought from the Newport works, when they were running, a lot of lead pipe for these connections, and it contained some peculiar chemical that our water had an effect on, and those pipes have been giving out from that day to this. This very last week we had trouble with one of our connections which came from that same lot of pipe. So you see there isn't any kind of pipe that is all

right. On the whole the lead pipe is the best of anything we have had, and we have never had any trouble with that, excepting with this thousand or two feet we bought for these connections; wherever they have given us trouble we have been able to trace it back to that lot of pipe. How, if the galvanizers have gone back on us, I think we will have to confine ourselves entirely to lead pipe. Our water has the peculiarty of coating over lead pipe within two weeks after it is laid, and there is no trouble with it after that time.

MR. BRACKETT. I would like to ask Mr. Hawes if those lead pipes that were taken out were found to be eaten from the inside or the outside? I am interested, because I have had two cases recently of lead services which were pitted entirely through; for almost their entire length from the outside.

MR. HAWES. I won't be certain whether it was from the inside or the outside, but they were completely honeycombed.

MR. BRACKETT. A peculiar feature was that, so far as I could see, they were in an old section of the city, or in the suburbs where there had been no filling. There was no reason I could attribute it to, as arising from the soil. I tried to find some connection from the sewer near them, but I haven't been able to yet, and I cannot trace the lead pipe because we buy from a number of different parties, and it is impossible to tell where it came from. We also have had more or less trouble with block tin pipe. Block tin pipe when laid in filling will eat out in a very short time. People in the Back Bay section of the city were very much afraid of lead pipe, and they originally had block tin pipes put in, but we have had to take them all out long ago.

MR. W. M. HAWES. Of course different waters have different effects, and, perhaps, the chemical properties are different.

MR. ALLIS. I have noticed the effect of coating which has been spoken of, and this affects our pipe in a little while. I don't think I have ever heard of any case of trouble from the use of lead in Malden, but I have had an experience which perhaps some of the others present have also noticed. I had some pipe from a certain maker in Boston, and when we drove the tamping pin into the end of the pipe to spread it, it would split. That was a new thing to me, so I made an inquiry, and I found that in the manufacture, in running from hot lead to cold, it would sometimes fail to make a perfect joint. The parties told me to send back any coils which were poor in that way, and they would replace it.

MR. COGGESHALL. In New Bedford we use lead pipe exclusively, and my experience is similar to that which has been mentioned by Mr. Brackett. I do not know of a single case where we have had a pipe eaten from the inside, but perhaps in the last five years we have had three or four cases where in a very unaccountable way the lead seemed to be pitted from the outside. I remember very well some years ago a case similar to that Mr. Allis refers to in a place where there was a very long service pipe on which there occurred a number of leaks. We thought the pipe must have been burst by the water-hammer, but on digging it up we found one length of 50 feet was perfectly honeycombed; and after we took that coil out and substituted a new coil,

there was no trouble with it. It was one of those cases of poor pipe that Mr. Allis speaks of.

MR. WHITNEY. I have lately heard an explanation of the reason why block tin pipe pits, as it sometimes does. The explanation given was that the English tin plate makers, for the sake of a little additional profit, had the habit of dipping a few plates in every lot of tin, and that the loss of the tin was almost counterbalanced by the particles of iron which came off from the plate as it was dipped, and these particles of iron in the tin, of course, rust, oxidized, as soon as they come in contact with the water, and make these pits. It seems rather curious, and I have no means of knowing whether it is the fact or not, although this gentlemen who told me is interested in metals, and in his travels through Europe he undoubtedly went into the factories there.

MR. MEYER. Upon this matter of a rigid connection with the main, I remember the superintendent of the Williamsburg Gaslight Co., once showed me some special couplings, made of composition, that he used to connect his services with the gas mains. He said he went to that expense because of the difficulty they had experienced from the services breaking at the connections, and in the past year or two since we began to building sub-ways in New York a large amount of leakage of gas has been found in our streets, and that came, I understand, largely from the service connection. From what I have heard and seen I think it is hardly wise to advocate the use of rigid wrought iron connections for the sake of saving a dollar on a service. I think it will be very apt to be found when tin pipe is eaten from the outside, that is in limy soil.

THE PRESIDENT. I would ask Mr. Milne, formerly Water Purveyor of Brooklyn, N. Y,, what his experience may have been.

MR. MILNE. I have had some little experience, and have come to the conclusion that a rigid connection is not practicable, for the reason that it is rigid, and that all ditches will inevitably settle, no matter what precaution has been taken in back-filling. A lead pipe is the only pipe that has the the elements of flexibility that is serviceable. The discussion that I have listened to this evening takes in a wide range regarding the characteristics of metals used in connection with service pipes. It is a well know fact that there is a galvanic action between brass metals and iron pipe. The gentleman on my left alludes to the fact that in a short time the pipe becomes obstructed with rust. That rust is simply the oxide of iron affiliating with the elements of brass which have become disintegrated. The same action also prevails in galvanized iron pipe. The sulphates of zinc find their affinity in the oxide of iron, and the result is under soft water administration, hard tubercular deposits, which in a very short time show themselves in the pipe. And so with wrought iron, an ordinary wrought iron pipe is a little longer in its life period when galvanized, and that is an important question to be considered by men who have to do with water works superintendence. I am led to the conclusion that lead pipe is perhaps the most durable pipe that can be used in a system of water works distribution.

MR. HOLDEN. My reasons for advocating the use of pipe without the lead

connections was due to having such remarkable good results from it; and, on talking with Mr. Nevons and Mr. Darling one day, I found they never used lead connections, or rarely used them. That was the reason for my bringing up this matter, because it seemed that there might be other places that are situated similarly to Pawtucket, to Cambridge and to Nashua, with the same kind of soil and water, where they might use it to as good advantage as we do.

MR. ALLIS. I would like Mr. Holden to tell the convention the way he puts in his services.

MR. HOLDEN. We have the proper kind of material there for putting in our services at very little expense. My manner of putting in service pipe in the principal part of the city is to dig a trench from the main to the sidewalk, that is usually about the length of the service pipe, and then tap the main, put in a corporation cock, take a piece of inch hose about 20 feet long with a union on both ends, connect one end of the hose to the corporation cock and the other end on to a length of galvanized pipe, one man turns on the water at the corporation cock, and the other man takes the pipe and pushes it right through the whole length; disconnects it, lays down another length of pipe, and connects it on, then connects the hose, and then, when the other man opens the cock, he pushes it still further. We find it very convenient in going under a nice lawn, for it saves digging, and we have frequently run as far as 50 feet in that manner. The expense of putting in a pipe in that way is very slight. Two men will frequently put in four supplies in a day.

THE PRESIDENT. The soil for the most part is sandy, isn't it?

MR. HOLDEN. The soil through the greater part of the city is either sand or sandy loam, and there I find that this arrangement works very well. Where we have gravel or cobbles we have to dig; but probably nine-tenths of supply pipes are put in without any digging at all, except in the street from the main to the sidewalk.

THE PRESIDENT. Just long enough to get a length of pipe into the trench?

MR. HOLDEN. About 16 feet long. Frequently when we are on the short side of the street, the men, rather than to dig will tunnel under the sidewalk as far as they can with the spade, perhaps cut the pipe off a little shorter and run to the supply below the cellar wall.

MR. BRACKETT. I would like to ask Mr. Holden how near he can come to his regular depth of 4 or 5 feet, in running 30 or 40 feet?

MR. HOLDEN. They come very close indeed. It is surprising how near a man who is used to the business can run.

MR. BRACKETT. He has different soil from the gentleman I have heard of who, in driving a well on the side of a hill, after driving a day or two, saw the point of the pipe appear down below coming up.

MR. HOLDEN. Our soil is entirely different from that. In some parts of our city there are cobble stones, where we can't lay pipe in that way, and we have to use a goose-neck. I judge that there is a similar soil in Cambridge; a great deal of it is marsh mud.

THE RELATIVE TASTE AND ODOR IMPARTED TO WATER BY SOME ALGÆ AND INFUSORIA.

BY

F. F. FORBES, Superintendent, Brookline, Mass.

The material for this paper which I have prepared, specially treating of the relative taste and odor imparted to water intended for domestic uses by those algæ and infusoria which are most frequently found in such waters, is obtained largely from studies in this direction which I have made during the past four or five years.

I have been able to find little recorded information bearing directly on this very important subject with the exception of brief descriptions of the growth of crenothrix and volvox in one or two places, and are fully aware that I cannot bring the experience of a number of other workers to corroborate some of the statements which I shall make.

This subject is yet in its very infancy. I hope to know much more about it in the future, but perhaps a partial record of my studies, incomplete as they are, may help others who are now plodding along the same way, either by giving some information or suggesting something which would not occur to them otherwise.

It is quite a general opinion among those who have not given the subject much study that different algæ and infusoria are quite alike as to the degree of trouble which they can bring to a water supply, the question only of the number of organisms to be considered.

Although these organisms are so minute that without the aid of the microscope they are wholly invisible to us except by aggregation, yet they have their individualities and characteristics as well as the larger plants which grow in our fields and pastures and the animals which feed on them. We are well aware how greatly the plants which are familiar to us differ—the violet with its own sweet perfume, the rose filling the morning air with its fragrance, and the heliotrope delighting all who approach it, and on the other hand the nettle with its sting, ever ready to poison those who venture near it, the homely dock smothering other plants around it, and the numerous weeds which cause the farmer so much hard toil. These few examples plainly show us the great difference in plant life—the same holds true in animal life.

Now as we descend to the lower levels of the vegetable and animal world, we find differences—not in so marked a degree perhaps, but the more we study these differences the more surprised we become that nature should bestow so much care on detail on such minute and at first thought unimportant objects.

Often as I have gazed through the microscope at these wonderful works of nature so complete in every particular, feelings similar to those experienced at viewing a quiet sunset from the summit of some hill or mountain come over me. The mysterious works of nature are in this way brought home to one and we almost fancy we can grasp and tear away that something with which nature veils her innermost self from our view.

But to return to the main object of this paper. I find from my studies that some algæ cause a much greater amount of annoyance than others—organism for organism.

The Brookline reservoir has furnished me an excellent opportunity for investigation in this direction.

During the years I have regularly made microscopic examinations of the water stored here, there have been periods when nearly the whole growth was confined to the individuals of a single species—in other words, there was nearly a pure culture of a certain organism and in fact with most of the organisms considered in this paper not one such growth but several.

It will thus be seen that the opportunity to judge of the effect which these different growths had upon the water, as far as imparting any ordor or taste to it has been a good one and not only had I to trust my own senses in the matter, but the water takers of Brookline kindly or unkindly came to my assistance. I now know pretty accurately how many organisms of certain species to a c. c. of water the average water consumer will drink without complaint or in fact without being aware of their presence at all. It seems important to go somewhat into detail in describing some of the growths just mentioned.

Of all the organisms which have come under my observation the uvella (an infusorium) is the most to be dreaded. The taste which uvella gives differs decidedly from any other. There seems to be something almost acid about it. It is exceedingly disagreeable and consequently at once detected.

In 50 c. c. of water, 500 colonies or about 10,000 individuals will make the water unfit to drink, and one-fourth of this number will cause the superintendent no little trouble.

In December of 1890 with the above number in the Brookline reservoir this water could not be used and the town's supply was received from the pumps, necessitating their use the whole 24 hours and thus adding largely to the maintenance account.

Practically there was no other organism present at this time.

In the following March when the uvella had disappeared and the growth was as follows—

17,000 Pandorina Morum,
70,000 Asterionella,
1,400 Synedra,
1,400 Raphidium,

a total number of 89,800 organisms, the pumping time was reduced one-half, no complaints came from the consumers, and little taste or smell could be detected on examination. As far as my observation goes in this case and in every other where uvella is present, the odor comes from the organism during its life and not after death or at least before decay commences. In the case just cited, the water was not changed in the reservoir from the appearance of this organism to the time of its disappearance and the water was perfectly good immediately after; and furthermore during its growth it frequently happened that not a single colony of this organism was found near the surface

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but in large numbers near the bottom, and at other times just the opposite would be true, but wherever uvella was present that peculiar unpleasant taste could be detected at once, and this taste always disappeared with the organism.

The organism which would probably rank next to uvella is volvox, but having had no chance to study this alga in comparison with other organisms I can add nothing to what is already known about it.

Wherever it appears in any number it causes much trouble as in Rochester, N.Y., as described by Geo. W. Rafter in his paper "On the Fresh Water Algæ and their Relation to the Purity of Public Water Supplies."

The infusorium dinobryon claims our attention next. Seventy-five thousand of these organisms in 50 c. c. of water will check the use of water as a beverage to a large extent and not without good reason. Weak vegetable solutions are very favorable for its growth and it never occurs in fact where such solutions are absent. All the growths in the Brookline reservoir occurred after heavy rains had caused the Charles river to overflow the meadows in the vicinity of our filtering galleries, enough water leaking into a connecting conduit (which has now been removed) at such times to furnish sufficient food for these infusoria.

We now come to consider the diatom asterionella, an organism which is more generally distributed in all classes of water than any other, and as far as I have observed the chief among diatoms, as far as giving the water unpleasant tastes and odors is concerned 250,000 of these in 50 c. c. of water will make the water decidedly disagreeable.

The odor it gives is strictly fishy—in fact the most fishy odor I have found among algæ. I have had several opportunities to study this diatom by itself and feel that I know it pretty well. As just stated it is found in nearly all classes of water, but it seems to prefer ground or spring waters, and the rapidity with which it often grows in the waters last mentioned is perfectly marvelous.

I shall now call your attention to a few organisms not so troublesome as those just mentioned.

First a species of Synedra, probably Synedra Pulchella.

This organism gives little taste to the water. I will copy from my notes as follows:

BROOKLINE RESERVOIR, May 26, 1890.

There is little algæ in the reservoir except diatoms, which are probably Synedra Pulchella.

This diatom seems to impart less odor than any other diatom I have yet been able to find growing alone in a body of water.

The slide was covered thick with them but I could detect no odor, and what is surer evidence there are no complaints from the consumer. At this date the number of Synedra was about 450,000.

In April of this year there were larger numbers of this diatom but little or no trouble was caused by them. Although they have visited the Brookline reservoir several times their reputation has been uniformly good, especially for an alga.

A small round diatom about one-quarter the diameter of cyclotella which often appear in reservoirs in large numbers, in the Brookline reservoir sometimes as high as 570,000, are hardly detected by any odor they impart.

Pandorina Morum is sometimes quite abundant but is not a harmful organism, and here let me again copy from my notes:

BROOKLINE RESERVOIR, May 9, 1890.

Samples taken about 9 a. m. I noticed one unusual thing this morning and one which deserves more than passing notice.

On the western side of the reservoir, the side on which the morning sun first shone, the stones were quite green—nothing of this kind was observed the day before. This proved to be Pandorina Morum apparently basking in the sunshine; and copying still farther, although I had a large mass of them on my slide, I could detect no smell, whereas if the same number of uvella was present the odor would have been something terrible, and an equal number of asterionella would have made the water undrinkable. Since this date I have had two or three oppportunities to study this growth by itself, but always with the same result as just described.

There are few organisms which are more thickly surrounded by jelly than Pandorina Morum, and if jelly was any indication of bad taste or odor, visits from these organisms would not soon be forgotten. They appear, however, to be quite harmless.

Glenodinium, an infusorium, seems to be kindly disposed to the water consumer. This is quite common in winter, living usually just under the ice.

And let me again quote from my notes:

BROOKLINE RESERVOIR, Feb. 6, 1891.

In the surface sample there were a great number of Glenodinia, and let me note here that the sample with so many Glenodinia had little odor, not as much as the other two samples, which contained very few of this organism, and the asterionella present would give all the odor observed. In fact, I could trace no odor to this infusorium. The life in these samples was as follows:

	Asterionella.	Small Round Diatom.	Glenodinium.
Surface	56,800	56,700	159,330
Half-way down	75,812	77,000	1,788
Bottom	82,360	113,000	852

I have had many other chances to observe the organism but the results have been the same as just cited.

I shall confine myself in this paper largely to the organisms which grow in the Brookline reservoir for two reasons: first, my opportunities for study here are much superior; and second, the water as it leaves the filtering galleries is practically free from taste and odor and organic matter, and the taste and odor which appear after the water is pumped into the reservoir is traceable directly to the algæ which then grow in it. Brookline is a good example of ground water.

In surface waters, the water itself from standing in contact with more or less

vegetable matter, often has a taste traceable to this, and it is not as easy perhaps to separate this taste from that caused by a certain algæ.

Tabellaria, Melosira, Stephanodiscus, Cyclotella and Synedra, which are common in surface waters, are not to be dreaded as much as asterionella by any means.

At the commencement of this paper, the question whether or not the unpleasant taste caused by algæ occurred only after death, was briefly alluded to, and in the case of uvella it was plainly shown that during its life, and not after, the mischief was done.

The same is true with all the algæ and infusoria which have visited the Brookline reservoir.

With the disappearance of the numerous growths the unpleasant taste disappeared also, and not in one instance has any taste appeared in the water supplied to the town which could not be traced to a certain organism or organisms.

From continuous microscopical examinations, now extending over several years, I think the above statement will apply to all or nearly all the grass green algæ, but from partial studies of the blue green algae different results in some cases at least may be expected.

Perhaps I ought to qualify somewhat the statement just made, if I have conveyed the idea that the organic matter which falls to the bottom of a reservoir on the death of the organism will remain there indefinitely without any harm coming from it. For a certain length of time after the disappearance of a large growth of algæ nothing may be heard from it, but later a growth like uvella, dinobryon, volvox, etc., may find food in this decomposing vegetable matter, and make trouble.

But I do wish to be understood in saying that decay of an alga or infusorium is not necessary before the water is made unpleasant by them.

So far I have endeavored to show chiefly how greatly some algæ and infusoria differ from other algæ and infusoria, and now I wish to say a few words in relation to the great importance of a regular biological examination of a water supplied to a town or city. I should like to see every superintendent possess enough knowledge of botany to study intelligently the common algæ which frequent water supplies for the following reasons:

1st. The water supplied to the consumer would be much more agreeable the year through without doubt. Each superintendent then would know what kind of organisms and how many were present at all times in the reservoir as accurately as he could distinguish and count the plants in his flower garden.

He could watch the different growths from their commencement to their end, and before they became numerous enough to be noticed by the consumer something might be done, either by pumping more hours per day in cases where the supply was obtained from ground sources; or in cases where the supply was from two or more ponds, basins or reservoirs, the pond, basin or reservoir not necessarily having the least number of organisms but those which were least troublesome could be drawn upon.

And again there is a great satisfaction in knowing all about the water supplied. If the water is disagreeable the superintendent knows just what causes

it and can speak and act intelligently with all inquirers, whilst otherwise he is like one groping in complete darkness. It seems to me that this whole subject is not receiving the attention it deserves.

Suppose that every water supply in this country was thoroughly studied from a biological point of view, and a record of these studies properly kept, what an amount of valuable information could be obtained.

After having determined what organisms are least objectionable, the next step if algæ of some kind must grow in all water exposed to sunshine is to make conditions favorable for the least objectionable class and not for those which give the most trouble.

This is a hard problem but continued study will surely bring us some light and if an absolute cure is impossible a convalescent state may at least be expected.

Studies have told us many of the favorable conditions for the growth of crenothrix.

Plants of the nostic family will not grow unless a large amount of organic matter is undergoing decomposition. Volvox will not thrive in ground waters.

Dinobryon will not grow without a weak vegetable solution.

My studies of the algæ and infusoria in the Brookline reservoir in comparison with similar growths in other bodies of water have suggested an idea which may at some later time when this subject is better understood prove to be of some help.

It appears that when the conditions are equally favorable for several, those which get possession first keep all others from the field, and when the conditions are more favorable for some one this one starves the others out.

The Indian has disappeared before the white man, and this same principle seems to extend all the way down, and include the algæ. If we must have at some times, or all times, algæ in our open reservoirs, bearing what has been said in mind, is it not in the range of possibilities to satisfy the economic ideas of nature by having only the least objectionable growths.

We know we cannot raise wheat or corn without hoeing the weeds out. We can't very well use such means to rid our reservoirs of troublesome algæ, but in addition to what can be done by removing food from the troublesome ones perhaps a little food which will just suit the palate of those less objectionable could be added and in such a case these latter would drive all others out and faithfully guard against any invasions. This, however, is a question for the chemist and biologist to puzzle over together.

It is well to bear in mind that it is not necessarily the number of organisms as much as the kind of organisms which cause the most trouble.

It seems to me that in the near future to those called to plan or maintain water supplies, something more than a knowledge of hydraulic engineering will be required. One must have some knowledge of botany and biology. In closing this paper let me say a few words of encouragement to those who are beginning or about to begin studies in this important branch of water supplies.

The work when commenced is a most fascinating one.

The microscope reveals to us a field as new and interesting as can well be imagined.

Views are obtained as wonderful, beautiful and interesting as the more bold works of nature when seen from a summit of some high mountain.

As we watch those silent forms, unconsciously doing a work that no chemist can do in the most completely equipped laboratory– a work without which this world to-day would be nothing but a mass of rock, gravel and sand—a work on which the whole animal kingdom depends for its existence, this subject becomes brimful of interest. It is like communing with nature face to face. The drudgery connected with it is like the toil climbing a steep rugged mountain, richly paid when the grandeur of nature's work is spread out before one's view.

DISCUSSION.

THE PRESIDENT. We have all of us been very much interested in Mr. Forbes's paper, and I think he will now be willing to answer any questions that any member may desire to ask him.

MR. STEARNS. Mr. President, I don't know that I can ask any questions, and I certainly cannot say anything on this subject that will be of any special value, because I have not used a microscope myself at all to study the individual organisms. But I do wish, however, to speak one word in addition to this paper. It seems to me that this work by some one who is directly connected with water works, who knows just the tastes and troubles they have from these forms, and who has opportunity on the spot to discover which forms give the most trouble, is of very great importance. I do not know but we might almost wish that Mr. Forbes's reservoir would raise the blue greens so he might study those too. (Laughter.) I suppose we have as much trouble from those as from any other kind, such as they have in the Brockton reservoir, and the Springfield reservoir, and many other places in the State. Those forms will not grow, I believe, in ground water; we have never found them there. It seems to me that all these little bits of information we get here and there will enable us to avoid the mistakes which have been made in the past in the construction of reservoirs, and that we can in the future, as we gain more and more knowledge, build our works with much greater certainty of success.

With reference to the diatom asterionella, I will say we have had samples from two places this spring, one a ground water reservoir, and the other a large storage reservoir, where they have had complaint of the character of the water, and in both cases it was found that the samples contained a very large number of asterionella. Our biologist told me a few days ago that he had an equal number of synedra in a bottle, and he could get no odor at all from them. It has been a question among those who have examined the matter as to whether it was the live organisms or the death of the organisms that caused the trouble; that is a point that Mr. Forbes hasn't touched, and I think it is, perhaps, not an entirely settled point yet. I know in three samples that came from this ground water reservoir, that the two samples from the pipes had more odor than the one from the reservoir, and after remaining two days in

the bottle the one from the reservoir had still more odor. It seemed almost to indicate in that case that the organism through its decay, or for some other reason, was giving a much stronger odor at one time than at another.

MR. FORBES. I would like to ask Mr. Stearns, in the case he has just referred to, whether the samples were taken at the surface, or what depth. As I said, there have been many times during the prevalence of the uvella, when some days I would find not a single colony on the surface, and large numbers at the bottom. Other days they would be at the surface of the water and not at the bottom. If a sample were taken on a day when they were nearly all at the bottom, on examination we would find little odor or taste in the sample; whereas, the water going to the distribution might come from the bottom and might contain many more of the uvella. In that case the surface water at the reservoir and the water drawn at the faucet would differ largely, and the next day it might differ the other way. It is very important in these cases, it seems to me, to have the samples taken at different elevations, so we will know whether they are there or not.

MR. STEARNS. I think Mr. Forbes's statement is correct, it is of very great importance, but in this case I have no knowledge. The samples were sent in, one taken from the surface and the other two from the faucets in town, and there was nearly a pure culture of asterionella with very little else in it. I don't remember, however, the other organisms which were present, and there may have been some uvella.

MR. FORBES. If you were to find a very few of those uvella mixed with the other organisms, they would impart an exceedingly disagreeable smell and taste to the water.

MR. STEARNS. Now that we have heard Mr. Forbes's paper, we shall look for uvella the way we have in the past for blue greens.

MR. CHACE. I would like to express my appreciation of the value and importance of Mr. Forbes's paper, and I would ask him one or two questions for my own satisfaction, if he will permit me. I would like to ask if he finds scum on the surface of his reservoir ever and the same organisms in that scum on the surface as he finds in other parts; and if, in addition to these two or three species of diatoms he finds in any others a relation between the diatoms and the taste and odor of the water.

MR. FORBES. It is very rarely we have found any scum on our reservoir, unless it is a scum composed almost wholly of pollen grains. There have been other organisms in our reservoir, but we have never been able to get them by themselves so as to feel positively sure that they did impart a certain kind of odor. What I have given here have been growing by themselves, there was hardly anything else in the water, and we had these alone. I could draw water out of the reservoir and taste it there, then the water would run into the distribution, and I would inquire of my friends, or my friends would speak to me about it. I did not trust to my own senses altogether, but let the water go as it would go, and then inquired of my friends how they liked it. We have had other forms, but, as I say, those I have spoken of here we have had by themselves, so that I feel very sure that they did what I said they did with regard to imparting taste and odor. And I know that with 350,000 synedra the water is not very bad; it don't begin to be as bad as with 10,000 uvella, there is no comparison at all. People will drink 350,000 synedra without saying a word. (Laughter.)

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93,000.

A MARVELOUS TEST.

NEW YORK, June 8, 1891.

HON. ROBERT E. SMITH, Commissioner of Public Works, Providence, R. I.

DEAR SIR:—We have had the pleasure of furnishing your Department during the past ten years about 5,500 Crown Meters. In the last shipment of 50 ¾ Crown Meters furnished you, we sent five of our "A" style of Crown Meter. We write to ask you if your Department has tested any of that lot of meters, and, if so, will you kindly send us a copy of such test?

Yours very truly,
JOHN C. KELLEY, President.

[COPY.] DEPARTMENT OF PUBLIC WORKS.

ROBERT E. SMITH, Commissioner.
JOHN C. KELLEY, Esq., President National Meter Co., 252 Broadway, New York.

COMMISSIONER'S OFFICE, CITY HALL,
Providence, R. I., June 11, 1891.

DEAR SIR:—Your request of the 8th inst., for a copy of the test for accuracy of a ⅝ Crown Meter, "A" pattern, is received. Inclosed find copy of the test of meter No. 84,169.

Yours respectfully,
ROBERT E. SMITH, Commissioner.
By W. F. SLADE, Secretary.

Test for Accuracy 1-2 inch Crown Meter No. 84,169, "A" Pattern, March 31 and April 2 and 3, 1891.

WATER PRESSURE.	FAHR.	TIME. Hours.	Minutes.	Seconds.	METER.	TANK.	OUTLET. Brown & Sharpe Disk.	PER CENT.
70 lbs.	70 Deg.	..	4	...	10 feet.	623 lbs.	½ in.	.0
70 "	70 "	..	7	23	10 "	617 "	¼ "	0.8
70 "	70 "	..	30	5	10 "	618 "	⅛ "	0.9
70 "	70 "	..	22	20	2 "	124 "	1/16 "	0.4
70 "	70 "	1	13	20	2 "	127 "	1/32 "	1.9
70 "	70 "	2	43	..	2 "	126 "	1/50 "	1.2
70 "	70 "	3	23	..	1 "	64 "	1/75 "	2.7
70 "	70 "	5	50	.	1 "	64½ "	1/100 "	3.5

WHAT DOES THIS TEST SIGNIFY?

One Cubic Foot of Water on 1-2 inch Stream was Registered in 24 Seconds.
" " " " 1/100 inch " " 21,000 "

The disks used were made by Brown & Sharpe Manufacturing Company.

NATIONAL METER COMPANY,

MANUFACTURERS OF

Crown, Empire, Gem and Nash Water Meters,

252 BROADWAY,

BOSTON, 159 Franklin Street. NEW YORK.

93,000

WATER METERS MADE AND SOLD.

DECEMBER, 1891. s.d.m.j.

PEET VALVE CO.,

MANUFACTURERS OF THE

Genuine Double Gate Peet Valves,

FOR STEAM, WATER, GAS, Etc.

Special Valves for all purposes Made to Order.

Peet Valve Co.,

163 Albany St.,

Boston, Mass.

s.d.m.j.

AUTOMATIC SUPPLEMENTARY OR DOUBLE VALVE
FIRE HYDRANTS.

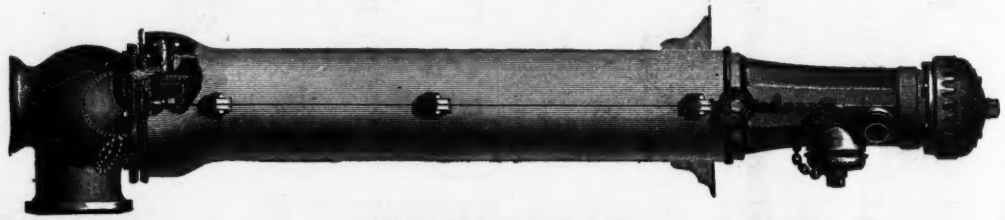
Patented 1878 and 1889.

The only successful automatic double valve hydrant ever constructed. Hundreds in use. In thirteen years no automatic valve ever failed to properly operate.

A NEW MAIN VALVE

can readily be inserted by one person in 30 minutes without shutting the water off or discharging any.

Also Constructed with Single Main Valve.



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Engineers,

Iron Founders,

and Machinists.

Office: 400 Chestnut Street, Philadelphia.

FIRE HYDRANT
With Crane Attachment for Sprinkling Cart.

s.d.m.j.

Foundries and Works: Millville, Florence, Camden, N. J.

Constructors of Water & Gas Works.

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—OF—

Cast Iron Pipe

TURBINE WHEELS,

Pumping Machinery,

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Lifts and Machinery,

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"Eddy" Valves,

"Mathews'" Hydrants

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Nos. 176, 178, 180, 182 and 184 HIGH STREET (Fort Hill Square),

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LEAD PIPE, TIN PIPE, SHEET LEAD,
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WHITE LEAD, Dry and in Oil, RED LEAD,
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☞**Lead encasing Electric Cables and Wires a Specialty.**

PROPRIETORS OF

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Correspondence with Water Works solicited.

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Has an unparalleled Record of more than Fifty Years.

SALES IN THE UNITED STATES, 7,000,000 BARRELS.

"HOFFMAN" ROSENDALE CEMENT.

FROM THE
BEST ROCK.
ADAPTED FOR
Heavy Masonry.
ALWAYS
RELIABLE.

STANDS EVERY
HIGH TEST.
UNIFORM IN
QUALITY
AND
Full Weight.

TAKES THE LEAD OF AMERICAN CEMENTS.

Extensively used by the U. S. Government.

Receives the approbation of the most eminent

ENGINEERS AND ARCHITECTS.

Send for Pamphlet of valuable information to

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Boston Lead Manufacturing Company,

Corner of Congress and Franklin Streets,

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Red Lead and Litharge Patent Tin-Lined Lead Pipe.

PURE BLOCK TIN PIPE.

Lead Pipe and Sheet Lead.

ALSO DEALERS IN

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SOLE PROPRIETORS AND MANUFACTURERS OF

CROSBY POP SAFETY VALVES and WATER RELIEF VALVES,

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BOSWORTH Feed Water Regulator and Pressure Regulator.

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s.d.m.j.

1891.

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LEAD PIPE.
True Centre.

SHEET LEAD.
Extra Width.

WIND TOWER

DROP AND CHILLED SHOT.

Buck Shot. Balls. Bar Lead.

PIG AND INGOT LEAD.

PIG AND BAR TIN. SOLDER.

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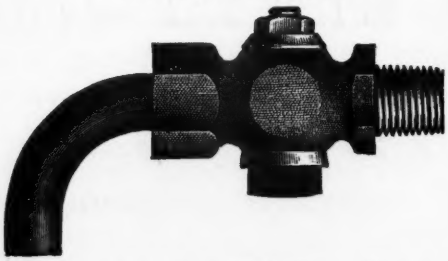

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d.m.j.s.

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Thomson Meter Co.,

(Sole Makers of the Thomson Water Meter),

211, 212 and 213 Temple Court Building,

NASSAU AND BEEKMAN STREETS,

NEW YORK.

A. D. 1891.

THOMSON METERS SOLD and DELIVERED:

April, - - -	1,008	July, - - - -	1,136
May, - - -	1,252	August, - - -	931
June, - - -	1,138	September, - -	907

Total for Six Months, 6,372. Average, 1,062 a Month.

WHAT DOES IT MEAN? THESE MONTHLY SALES EXPLAIN IT.

Whole Number Sold, 20,000.

CATALOGUE ON APPLICATION.

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UNION ✣ WATER ✣ METER ✣ CO.,

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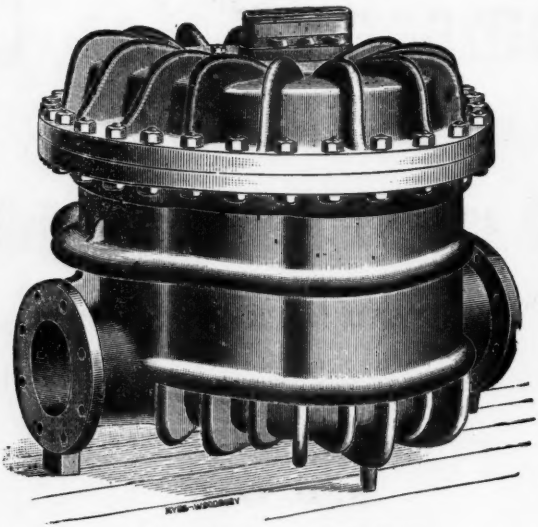
ESTABLISHED IN 1868.

Man'f'rs of the only positive

MEASURING 12-in. METERS.



Manufacturers of the **METER** most extensively used on Hydraulic Elevators, Locomotive Stand Pipes, &c.

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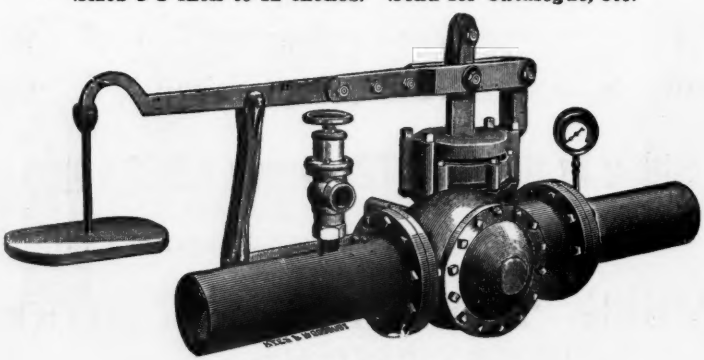
WATER METERS.

Sizes 5-8 inch to 12 inches. Send for Catalogue, etc.



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PIPE,

From 8 to 48 Inches Diameter.

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ALL SIZES OF FLANGED PIPE

— AND —

SPECIAL CASTINGS.

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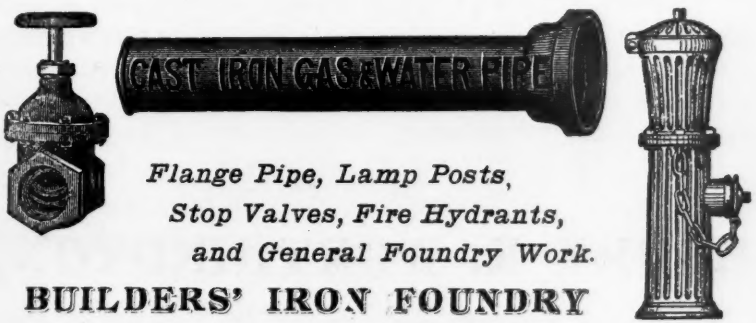

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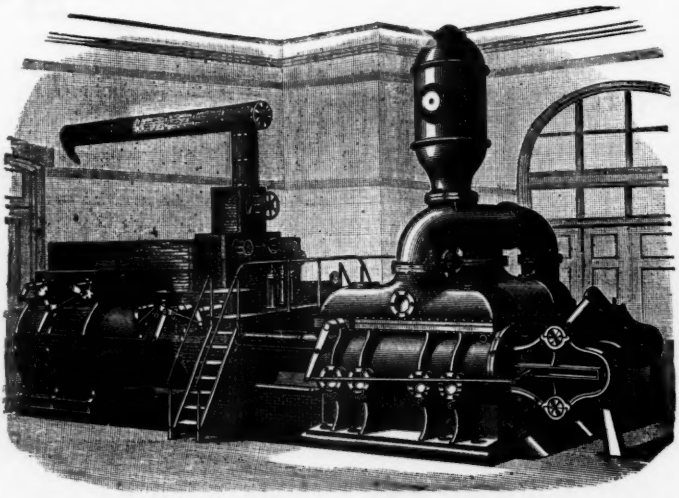

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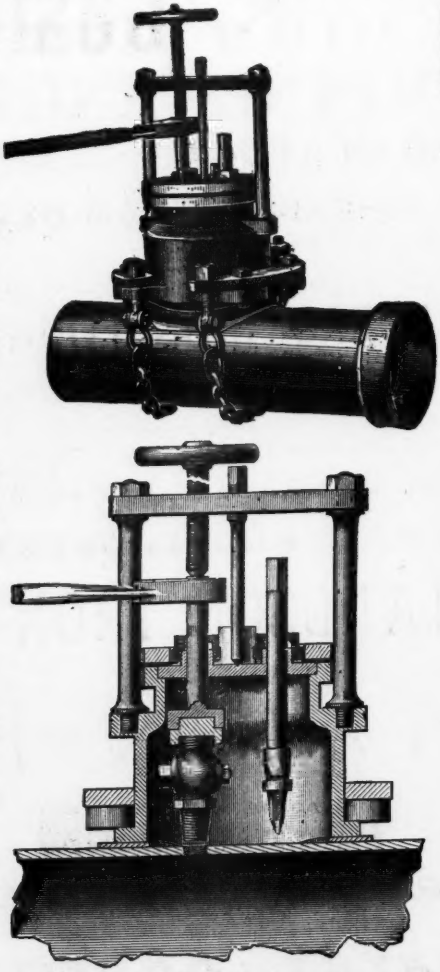
THE HALL TAPPING MACHINE (Patented.)



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Wrought and Cast Iron Pipe and Fittings. Brass Work of all kinds.
Water, Steam and Gas Fitters' Tools and Supplies.
Extension Shut-off Boxes. Straight-way and Hydrant Valves a Specialty.
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For tapping main pipes under pressure, ***Simplest and Best. Three Machines in One.*** Body made of Brass, Trimmings of Wrought Iron and Steel.

ALL GOODS GUARANTEED FIRST-CLASS.

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The Second Edition, 270 pages, 50 cuts and diagrams, of OFFICIAL REPORTS OF DUTY TRIALS by eminent engineers of 34 High Duty Pumping Engines, will soon be ready for Engineers and Water Works Officials.

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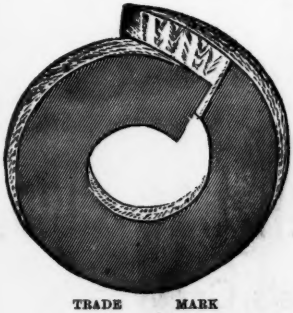

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Piston Rods, Valve Stem of Steam Engines, Steam Pumps, and Especially Adapted for Paper and Pulp Mills, Electric Light Plants, Water Works, &c.

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Less friction than any other known Packing. Never grows hard if directions are followed. Does not corrode the rod. *Every Package fully warranted.*

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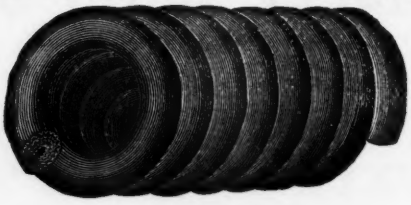

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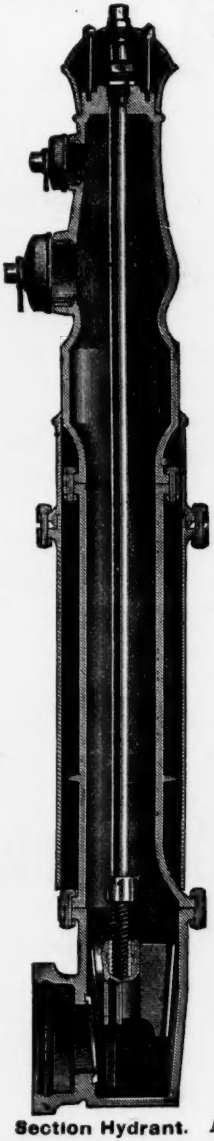

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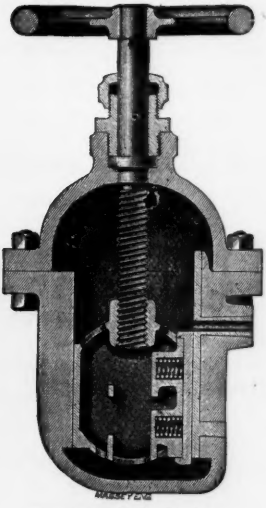

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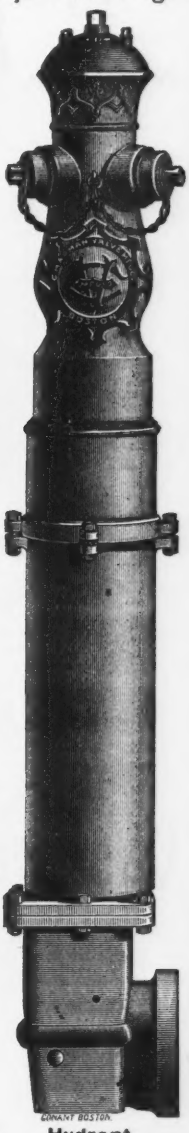

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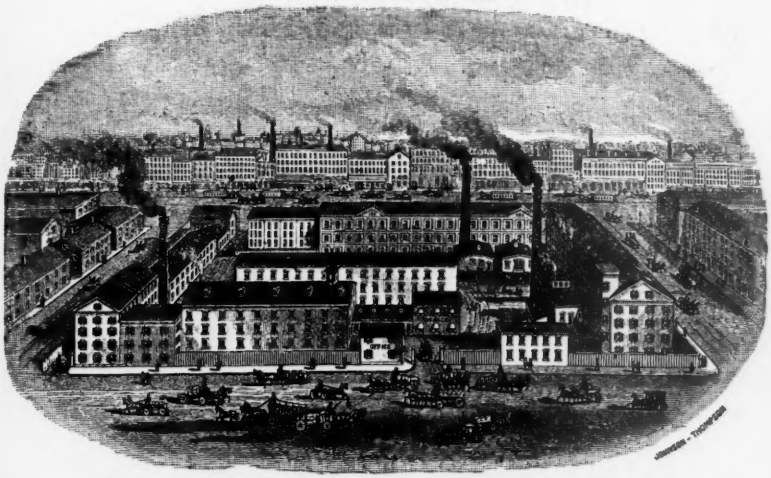

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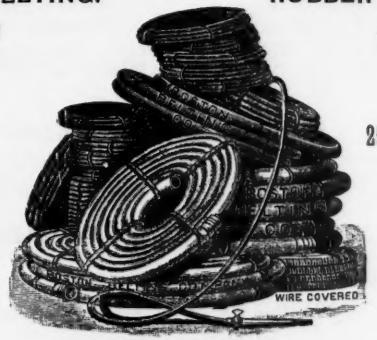

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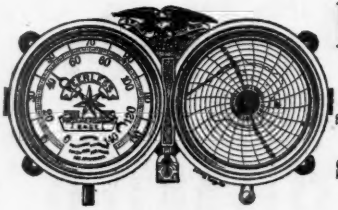

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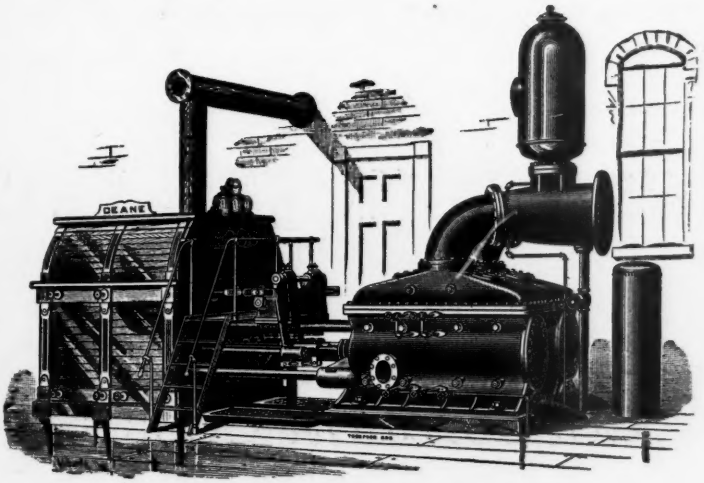

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